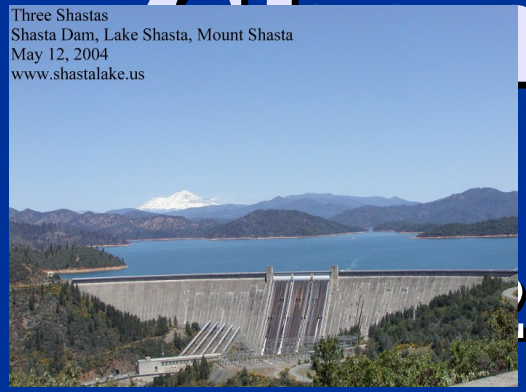
Reservoir Re-assessment and Re-allocation for Changing Climates



2008 Planning CoP

Stu Townsley, CESPK; Rolf Olsen, CEIWR; Marcia Hackett, CESWF; Ann Fissekis, CESPK

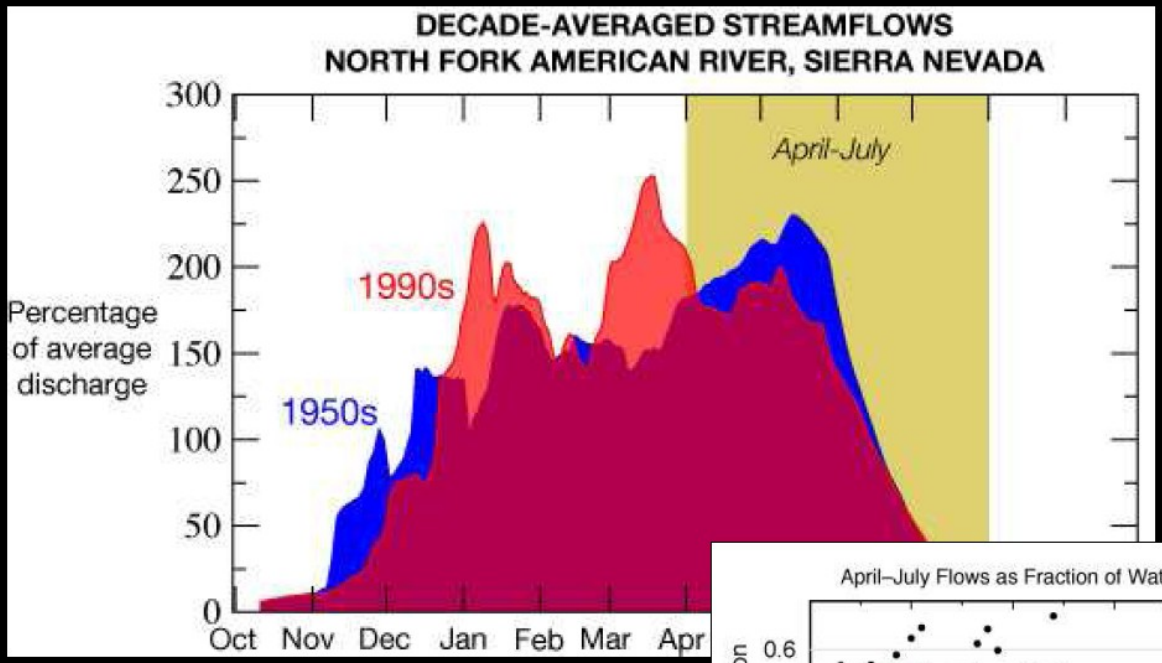
Water Management Section, Sacramento District, US Army Corps of Engineers

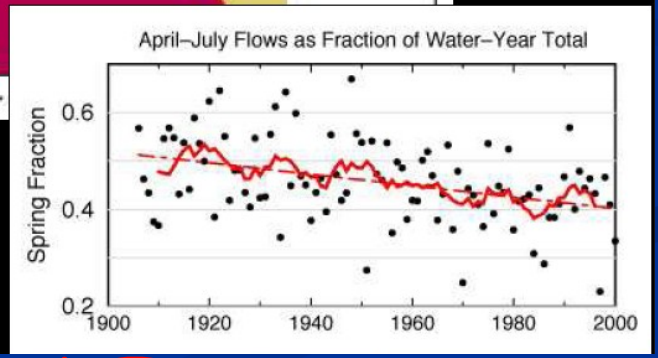
Why consider climate?

- Scientific literature shows potential climate-related trends
- Climate change is of interest to our sponsors, especially in the West and along the coasts
- C[illegible]o consider future c[illegible]

The future challenge for SPK

As a result of these trends, the warm-season fraction of annual streamflow has declined.





Roos, 1989, 1991; Dettinger and Cayan, 1995; Stewart et al 2005

Decrease in Spring Runoff

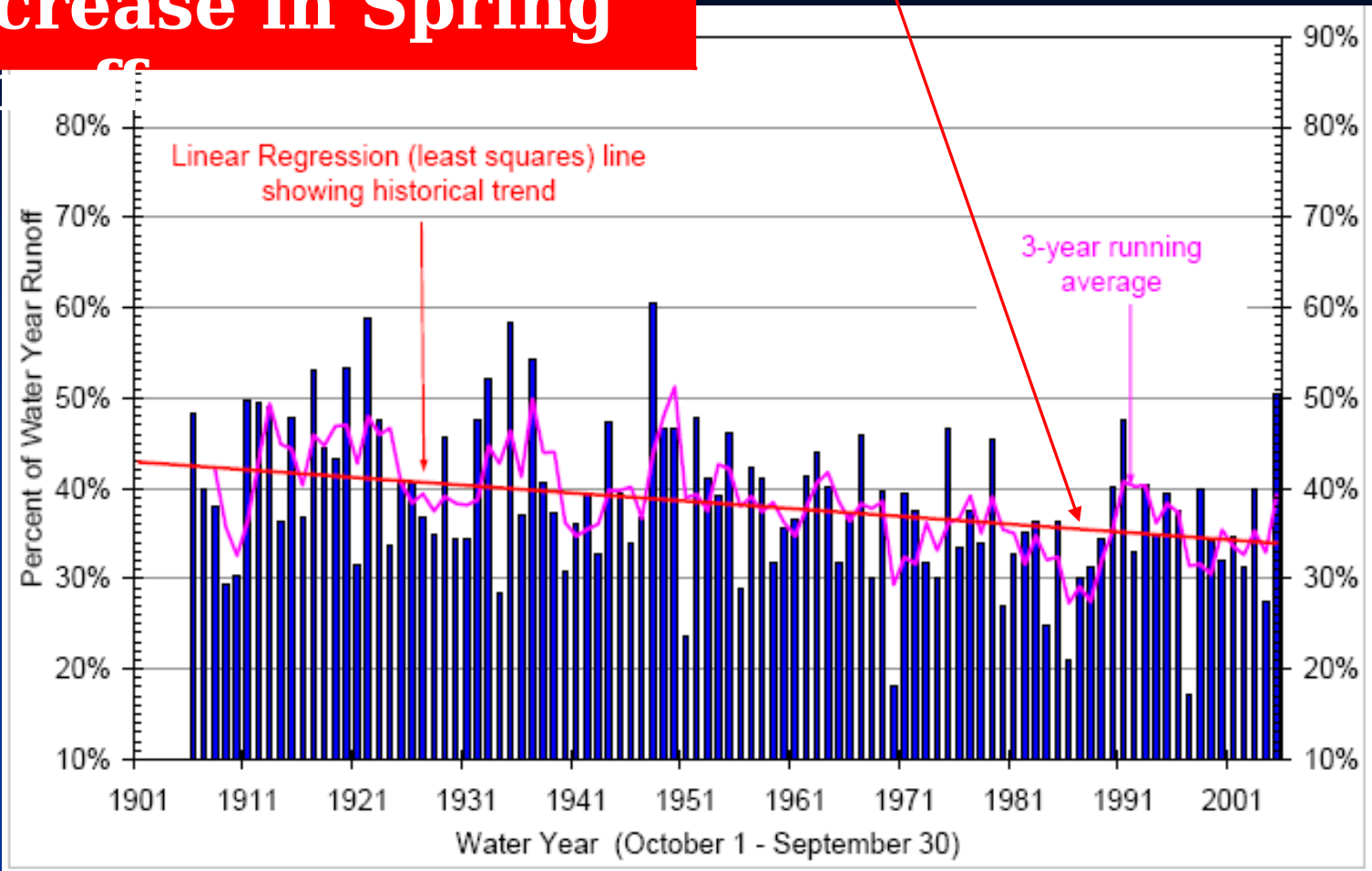


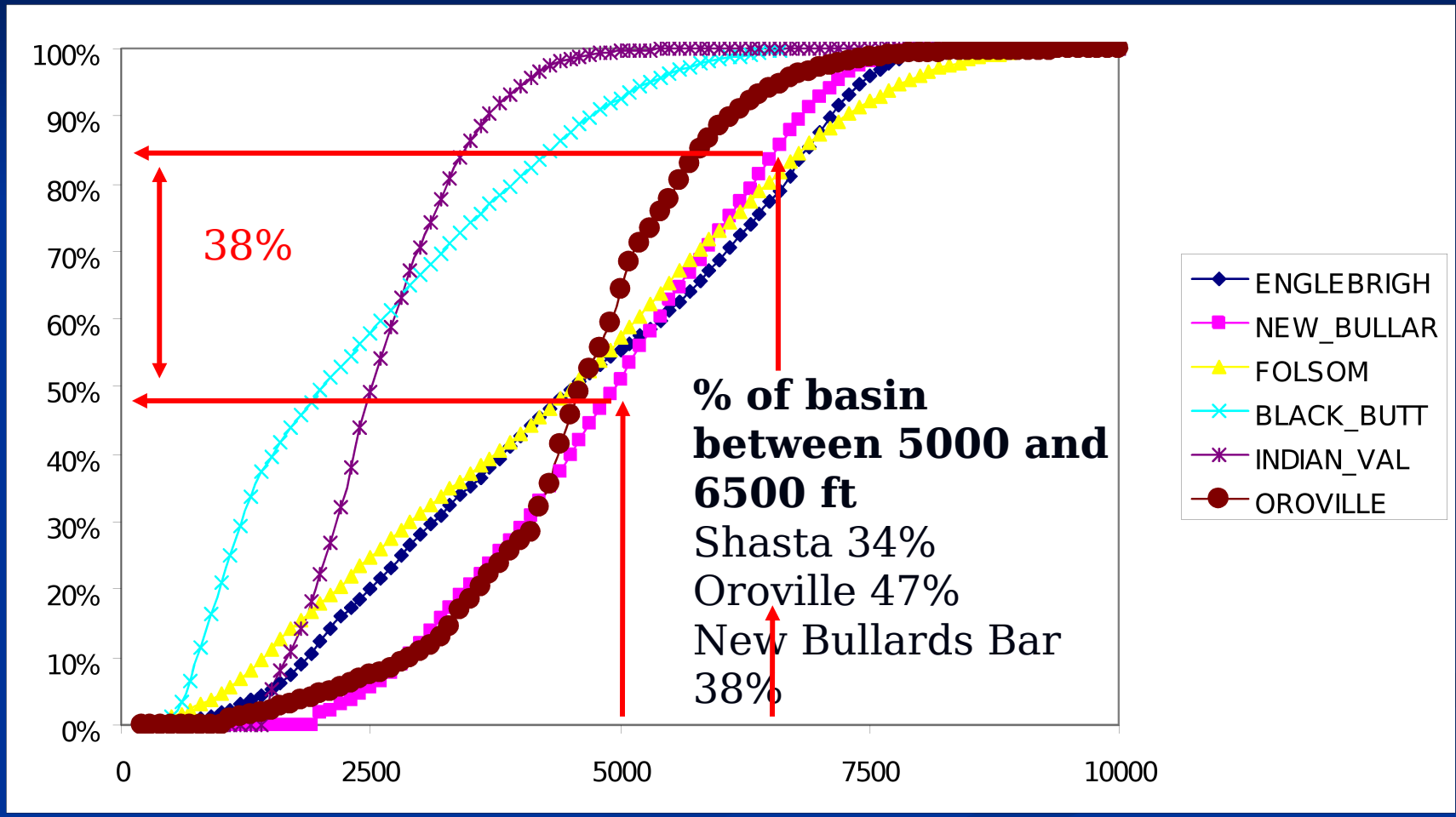
Figure 2-13 Annual April through July Unimpaired Runoff for Four Sacramento Valley Rivers Compared to Total Unimpaired Annual Runoff*

* Based on the flows of four rivers in the Sacramento Valley; Sacramento River at Bend Bridge (near Red Bluff), Feather River into Lake Oroville, Yuba River at Smartville, and American River below Lake Folsom.

Major Central Valley watersheds

- Shasta mean elevation: 4576 ft.
- Oroville mean elevation: 5030 ft.
- Ne
  me
  48

Sacramento Reservoir Elevation Percentages



Corps Authority

- Section 7 of the 1944 Flood Control Act
- 33 CFR 208.11
- Authoring legislation for water resource projects

If Federal dollars for flood damage reduction, then C has responsibility

But Corps does not own w just reservoir space

Reservoirs in CA

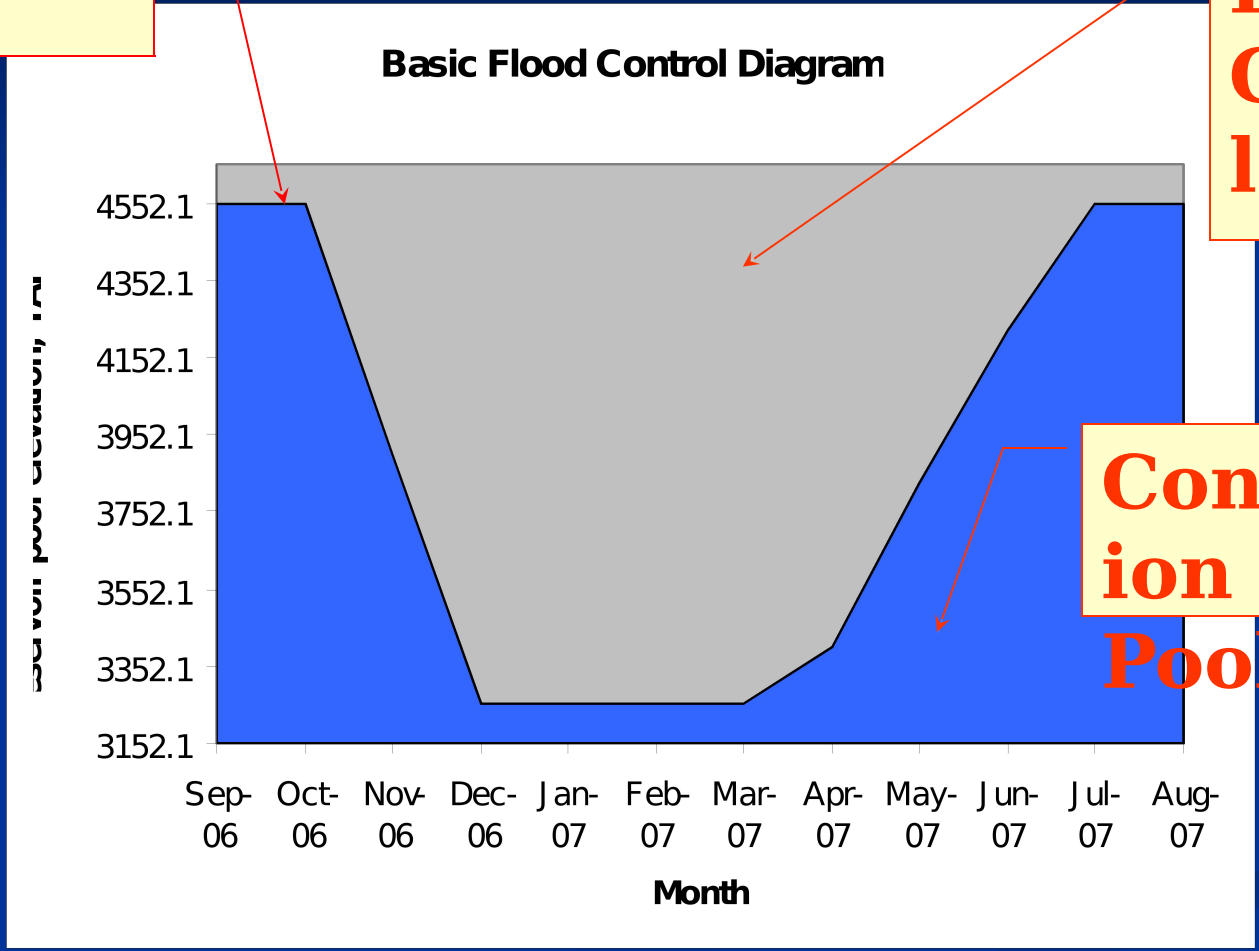
- 35 reservoirs (Corps e.g., Pine Flat, Isabella; Section 7 e.g., Shasta, Folsom, Oroville)
- Total storage ~ average annual runoff
- Flood space is seasonal
- Basic operation: reserve space, store when flows above targets, release soonest possible
- Operation governed by Flood Control Diagram
- For most part diagrams unchanged from authorization 50+ years

Conceptual rule curve

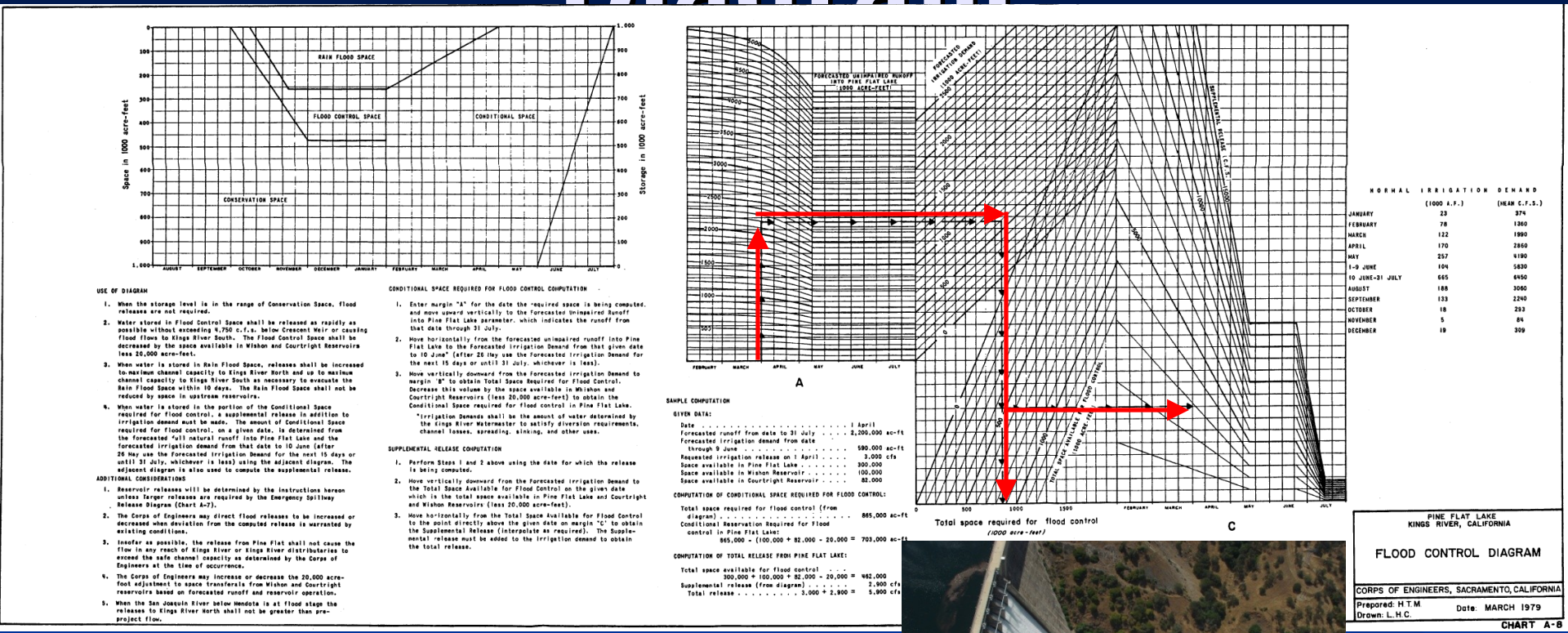
Rule Curve

Flood Control Pool

Conservation Pool



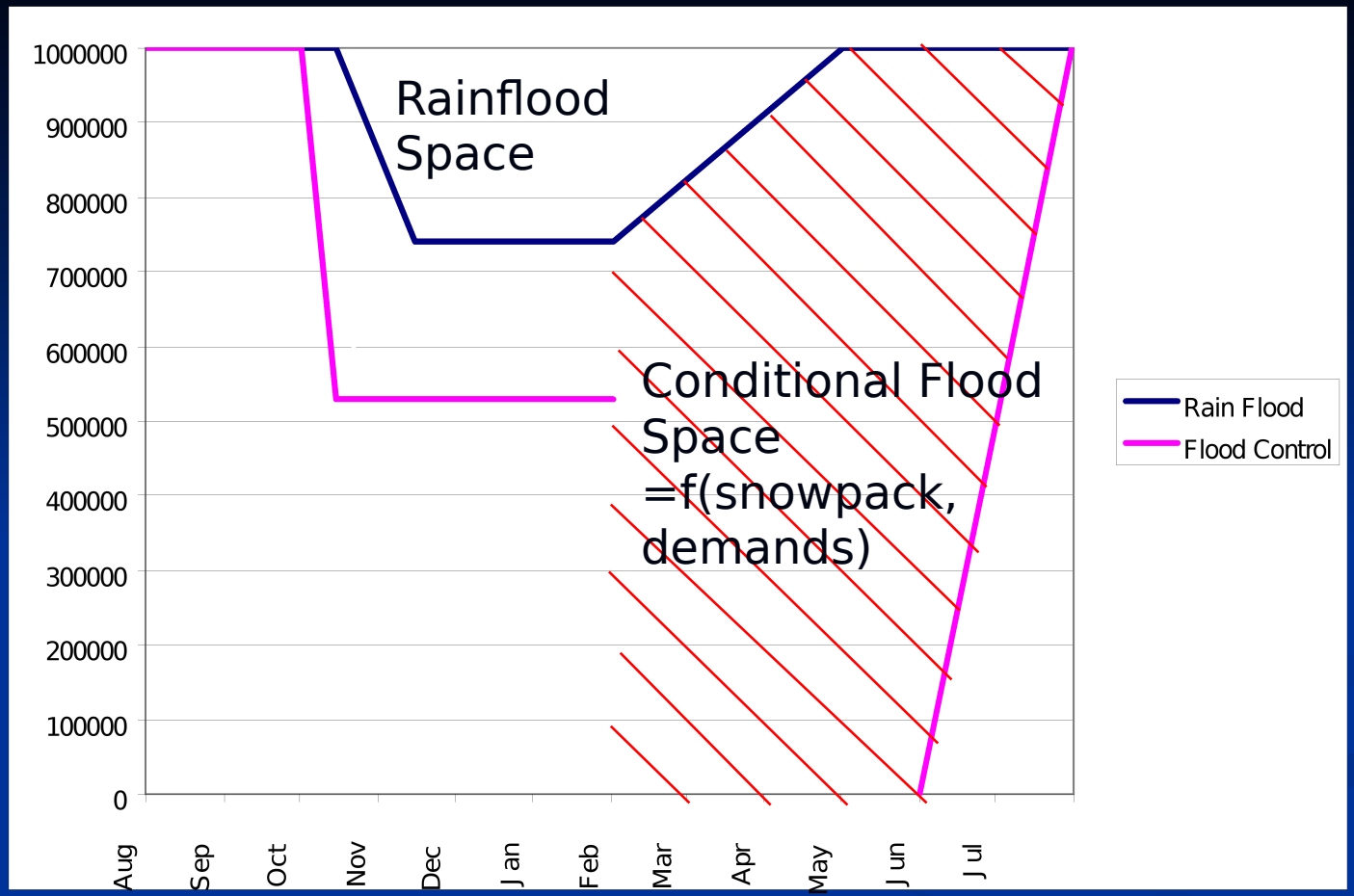
Pine Flat Flood Control Diagram


RAIN FLOOD SPACE
FLOOD CONTROL SPACE
CONDITIONAL SPACE
CONSERVATION SPACE
Space in 1000 acre-feet
Storage in 1000 acre-feet
AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY
USE OF DIAGRAM
1. When the storage level is in the range of Conservation Space, flood releases are not required.
2. Water stored in Flood Control Space shall be released as rapidly as possible without exceeding 9,750 c.f.s. below Crescent Weir or causing flood flows to Kings River South. The Flood Control Space shall be decreased by the space available in Wishon and Courtright Reservoirs less 20,000 acre-feet.
3. When water is stored in Rain Flood Space, releases shall be increased to maximum channel capacity to Kings River North and up to maximum channel capacity to Kings River South as necessary to evacuate the Rain Flood Space within 10 days. The Rain Flood Space shall not be reduced by space in upstream reservoirs.
4. When water is stored in the portion of the Conditional Space required for flood control, a supplemental release in addition to irrigation demand must be made. The amount of Conditional Space required for flood control, on a given date, is determined from the forecasted full natural runoff into Pine Flat Lake and the forecasted irrigation demand from that date to 10 June (after 26 May use the forecasted irrigation demand for the next 15 days or until 31 July, whichever is less) using the adjacent diagram. The adjacent diagram is also used to compute the supplemental release.
ADDITIONAL CONSIDERATIONS
1. Reservoir releases will be determined by the instructions hereon unless larger releases are required by the Emergency Spillway Release Diagram (Chart A-7).
2. The Corps of Engineers may direct flood releases to be increased or decreased when deviation from the computed release is warranted by existing conditions.
3. Insofar as possible, the release from Pine Flat shall not cause the flow in any reach of Kings River or Kings River distributaries to exceed the safe channel capacity as determined by the Corps of Engineers at the time of occurrence.
4. The Corps of Engineers may increase or decrease the 20,000 acre-foot adjustment to space transferals from Wishon and Courtright reservoirs based on forecasted runoff and reservoir operation.
5. When the San Joaquin River below Mendota is at flood stage the releases to Kings River North shall not be greater than pre-project flow.
CONDITIONAL SPACE REQUIRED FOR FLOOD CONTROL COMPUTATION
1. Enter margin "A" for the date the required space is being computed, and move upward vertically to the Forecasted Unimpaired Runoff into Pine Flat Lake parameter, which indicates the runoff from that date through 31 July.
2. Move horizontally from the forecasted unimpaired runoff into Pine Flat Lake to the Forecasted Irrigation Demand from that given date to 10 June* (after 26 May use the Forecasted Irrigation Demand for the next 15 days or until 31 July, whichever is less).
3. Move vertically downward from the Forecasted Irrigation Demand to margin "B" to obtain Total Space Required for Flood Control. Decrease this volume by the space available in Whishon and Courtright Reservoirs (less 20,000 acre-feet) to obtain the Conditional Space required for flood control in Pine Flat Lake.
*Irrigation Demands shall be the amount of water determined by the Kings River Watermaster to satisfy diversion requirements, channel losses, spreading, sinking, and other uses.
SUPPLEMENTAL RELEASE COMPUTATION
1. Perform Steps 1 and 2 above using the date for which the release is being computed.
2. Move vertically downward from the forecasted irrigation Demand to the Total Space Available for Flood Control on the given date which is the total space available in Pine Flat Lake and Courtright and Wishon Reservoirs (less 20,000 acre-feet).
3. Move horizontally from the Total Space Available for Flood Control to the point directly above the given date on margin "C" to obtain the Supplemental Release (interpolate as required). The Supplemental release must be added to the irrigation demand to obtain the total release.
FORECASTED UNIMPAIRED RUNOFF INTO PINE FLAT LAKE (1000 ACRE-FEET)
FORECASTED IRRIGATION DEMAND (1000 ACRE-FEET)
SUPPLEMENTAL RELEASE C.F.S.
FEBRUARY MARCH APRIL MAY JUNE JULY
A
SAMPLE COMPUTATION
GIVEN DATA:
Date . . . . . 1 April
Forecasted runoff from date to 31 July . . . . 2,200,000 ac-ft
Forecasted irrigation demand from date through 9 June . . . . . 590,000 ac-ft
Requested irrigation release on 1 April . . . . 3,000 cfs
Space available in Pine Flat Lake 300,000
Space available in Wishon Reservoir 100,000
Space available in Courtright Reservoir 82,000
COMPUTATION OF CONDITIONAL SPACE REQUIRED FOR FLOOD CONTROL:
Total space required for flood control (from diagram) . . . . . 865,000 ac-ft
Conditional Reservation Required for Flood control in Pine Flat Lake:
865,000 - (100,000 + 82,000 - 20,000 = 703,000 ac-ft
COMPUTATION OF TOTAL RELEASE FROM PINE FLAT LAKE:
Total space available for flood control . . . 300,000 + 100,000 + 82,000 - 20,000 = 462,000
Supplemental release (from diagram) . . . . . 2,900 cfs
Total release . . . . . 3,000 + 2,900 = 5,900 cfs
Total space required for flood control (1000 acre-feet)
B
C
NORMAL IRRIGATION DEMAND

	(1000 A.F.)	(MEAN C.F.S.)
JANUARY	23	374
FEBRUARY	78	1360
MARCH	122	1990
APRIL	170	2860
MAY	257	4190
1-9 JUNE	104	5830
10 JUNE-31 JULY	665	6450
AUGUST	188	3060
SEPTEMBER	133	2240
OCTOBER	18	293
NOVEMBER	5	84
DECEMBER	19	309

PINE FLAT LAKE
KINGS RIVER, CALIFORNIA
FLOOD CONTROL DIAGRAM
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: H.T.M. Date: MARCH 1979
Drawn: L.H.C.
CHART A-8

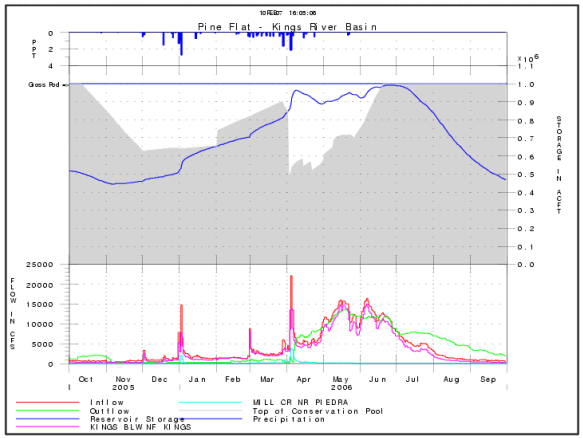
Typical snowmelt influenced rule



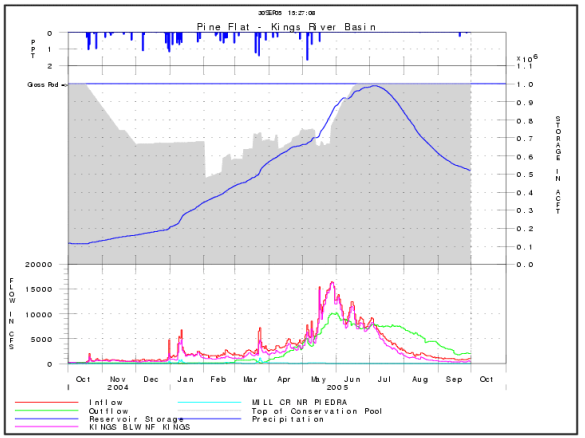
- Developed from historical record (look-back)
- Conditional space dependent on 120B, irrigatio
- Operation based on observed data (rainfall, sn

Pine Flat Operations

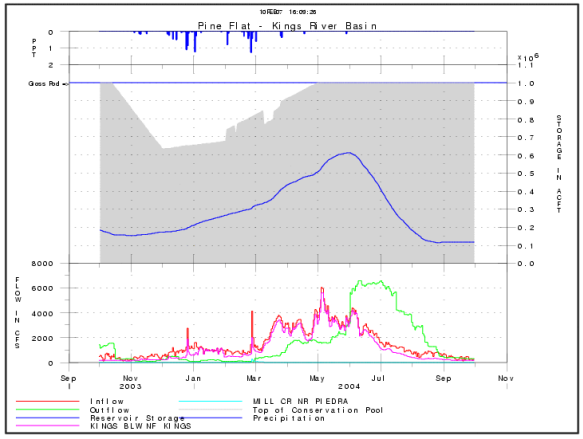
WY 200



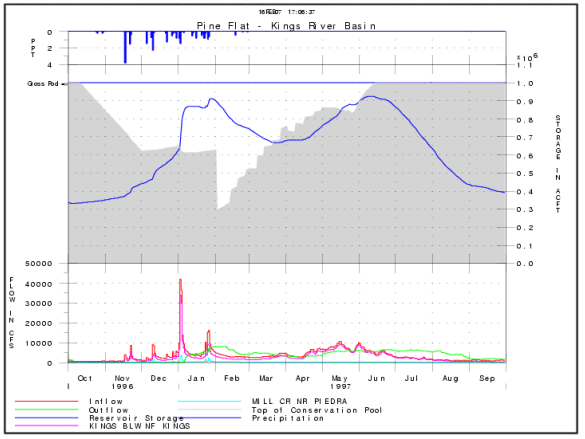
WY 2005



WY 200



WY 1997



Potential Flood Implications

- Literature suggests
  - Warmer regime, about the same annual precipitation
  - Smaller snowpack, earlier melt, flow shift
  - Greater storm variability
- Implications?
  - Need more rainflood spa
  - Allow earlier fill?

Historic data needs

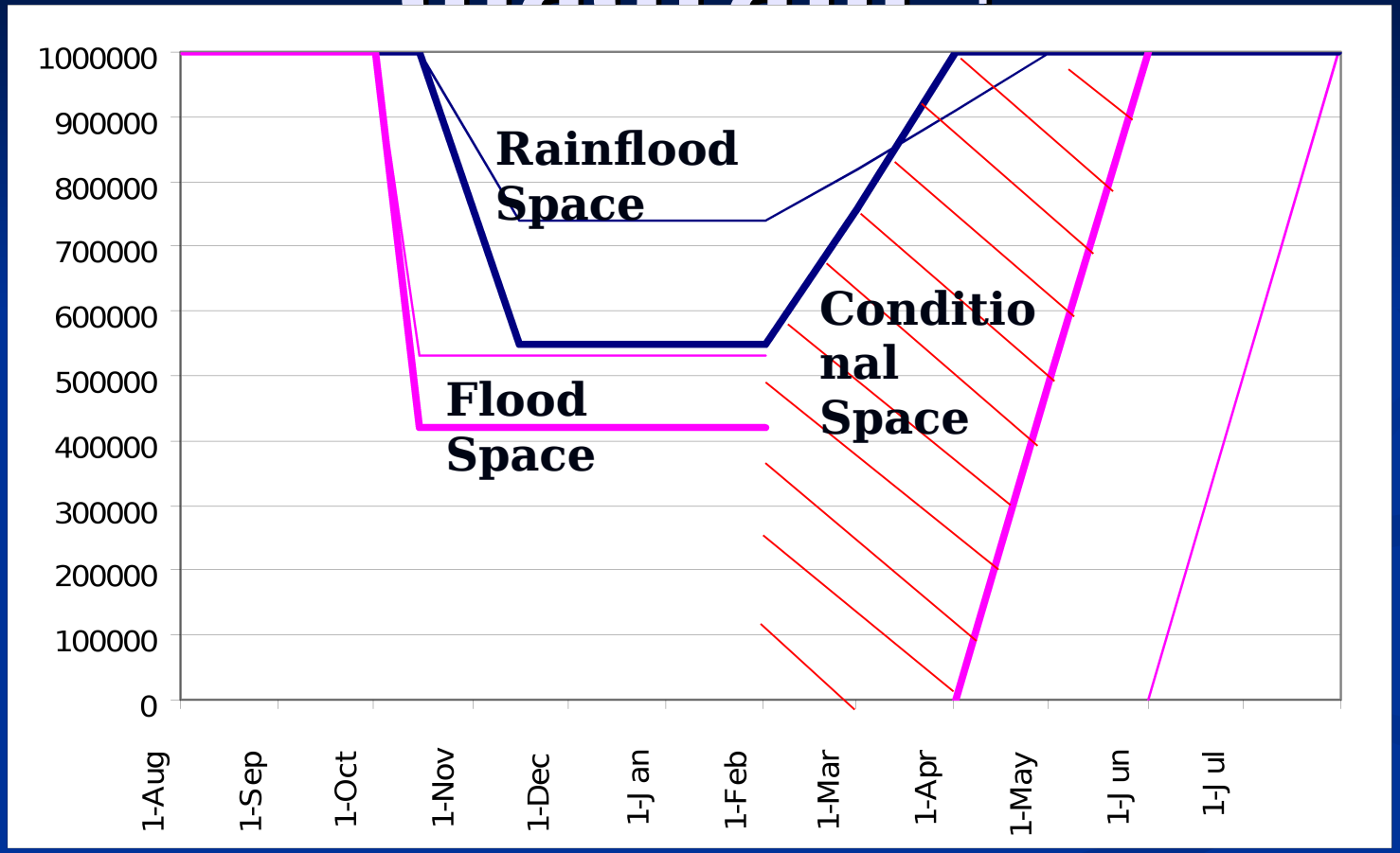
- Streamflow for reservoir syste
- Snow accumulation and melt p
- Irrigation and spreading dema
- Peak flow/volume duration cur

Does history give enough information to establish reliable trends for future flood operations?

Possible rule curve changes

- Magnitude for flood contr
- Draw-down timing
- Earlier refill schedule
- Forecast parameter that a
  flexibility to release decisi

Climate adjusted diagram ?



Jury still out – takes studies to resolve!

Methodology

- Analyze 22 GCM simulations for 2030 projected temperature and precipitation ranges under two climate scenarios
- Determine 10th, 50th and 90th temperature and precipitation percentiles by subbasin
- Generate reservoir inflows using perturbed temperature and precipitation input using NWS-RFS
- Test flood control curves using ResSim

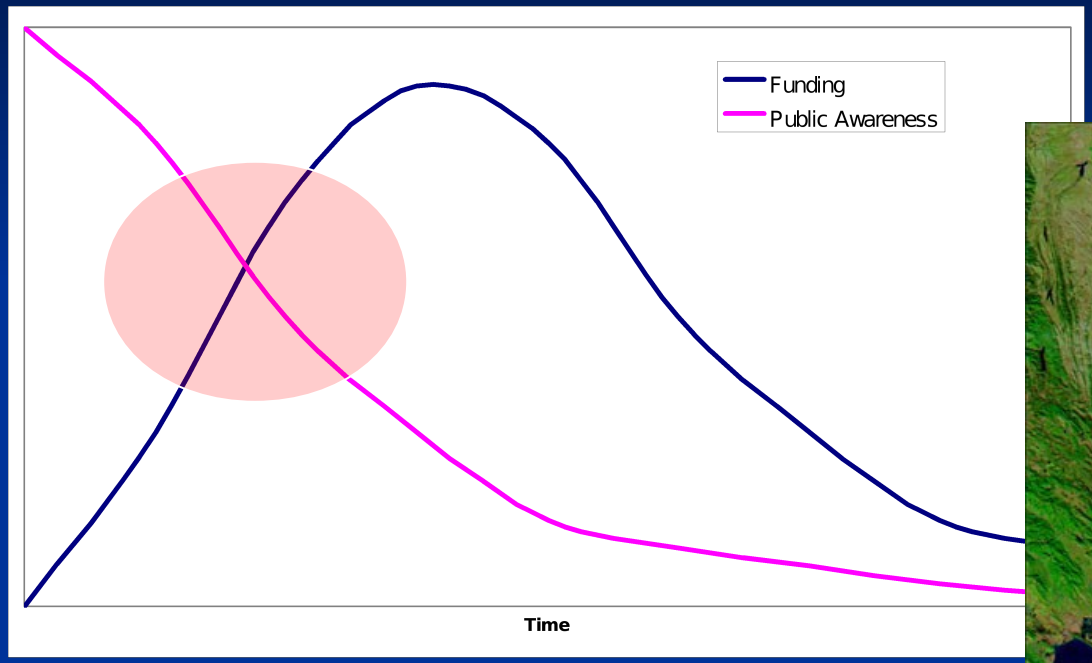
Temperature increments (°F)

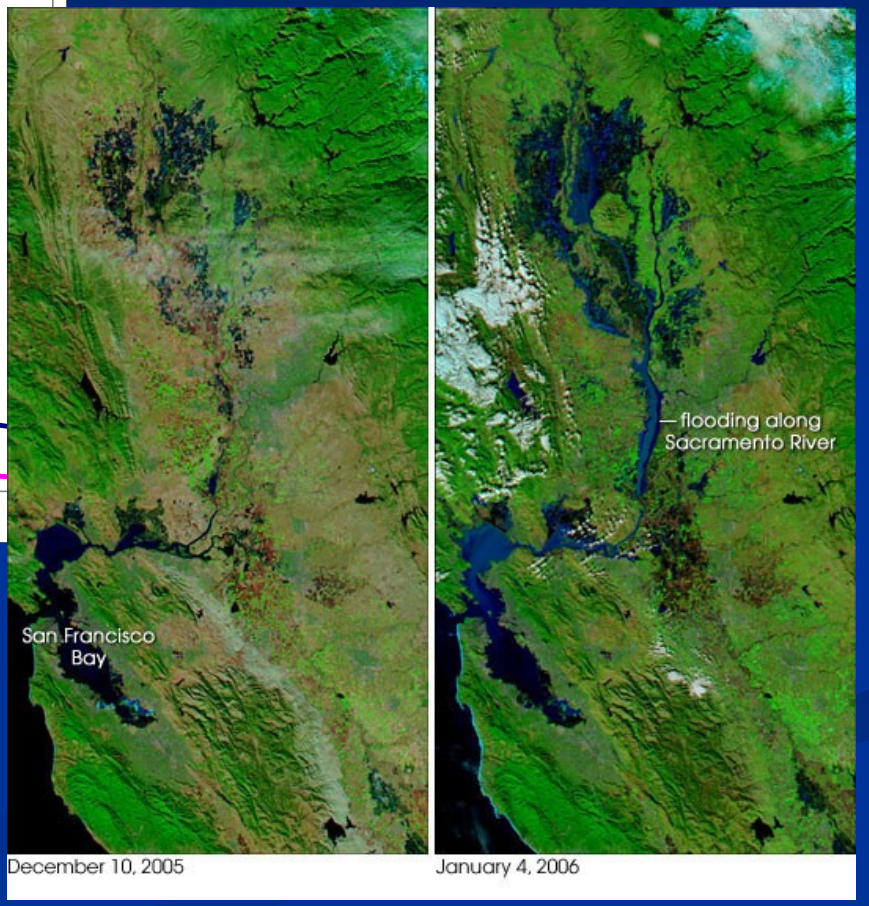
		percentile values		
		10th	**50th**	**90th**
Shasta subbasins	**cnbc**	0.784	1.946	2.661
	pitc	0.742	1.885	2.549
	dltc	0.726	1.613	2.402
	mssc	0.737	1.700	2.463
	shdc	0.730	1.652	2.396
Oroville subbasins	**mrmc**	0.804	1.900	2.476
	ordc	0.779	1.816	2.417
	iifc	0.817	1.973	2.574
	plgc	0.778	1.850	2.422
	pllc	0.783	1.898	2.508
	ftcc	0.838	1.982	2.598
New Bullards Bar subbasin	**nbbc**	0.802	1.901	2.489
mean		0.777	1.843	2.496

Precipitation change (%)

		percentile values		
		10th	50th	90th
Shasta subbasins	cnbc	-5.7%	4.8%	12.5%
	pitc	-5.7%	4.7%	15.5%
	dltc	-5.7%	3.7%	15.3%
	mssc	-5.7%	3.7%	15.2%
	shdc	-6.3%	3.9%	16.0%
Oroville subbasins	mrmc	-7.6%	5.2%	19.1%
	iifc	-7.1%	4.7%	18.5%
	ordc	-5.7%	3.7%	15.2%
	ftcc	-7.8%	5.1%	19.9%
	plgc	-7.1%	4.9%	17.7%
	pllc	-6.4%	4.4%	17.2%
New Bullards Bar subbasin	nbbc	-8.0%	5.0%	19.8%
	mean	-6.6%	4.5%	16.8%

Mount Action Curve





ER 1110-2-240 Water Control Management

The development of water control plans and the scheduling of reservoir releases must be coordinated with appropriate agencies, or entities, as necessary to meet commitments made during the planning and design of the project. **Additionally, water control plans must be reviewed and adjusted, when possible, to meet changing local conditions**.

EM 1110-2-1420 Hydrologic Engineering Requirements for Reservoirs

Congress commonly authorizes a project substantially in accordance with the recommendations of the Chief of Engineers", as detailed in a separate congressional document. **Later, additional purposes are sometimes added, deleted, or original purposes modified by subsequent congressional action.** When the original purposes are not seriously affected, or structural operational changes are not major, modifications may be made by the Chief of Engineers (Water Supply Act, 1958).

Updating diagrams in the real world

- Current Corps guidance – revisit every decade
- Project enhancement, e.g., Folsom, Terminus
- To date, only minor revisions to release rate of change limits, low flow enhancements
- Likely requires full EIS, Congressional reauthorization – big deal, big cost

What next?

- Planning study teams should start incorporating climate
- Studies should at least describe what the project can and cannot do in regards to climate change → articulate residual risk
- Updates to Water Control Manuals
- Climate models downscaled - better spatial and temporal resolution
- Forecast accuracy metrics

Collaborative process with partners

- Climate modelers – establish site-specific trends
- Operations modelers – dynamic tools
- DWR – financially responsible
- Water users – helping build political case
- Environmental interests – ditto

Goal: dynamic, transparent process for rule curve updates with a system perspective

Systems approach

- Watershed
- Engineered
- Economic
- Environmental
- Governmental

Supported by:

- Actions for Change
- 2007 Army Civil Works Legislative Program

Questions?